

DOCUMENT RESUME

ED 188 376

EC 124 219

AUTHOR Shigaki, Irene S.: Wolf, Willavene
 TITLE Formal Syllogistic Reasoning of Young Gifted Children.
 PUB DATE Apr 79
 NOTE 26p.: Paper presented at the Annual Meeting of the American Educational Research Association (Boston, MA, April, 1979).
 EDRS PRICE MF01 Plus Postage. PC Not Available from EDRS.
 DESCRIPTORS Age Differences; *Cognitive Processes; Elementary Education; Exceptional Child Research; *Gifted; *Logic; Logical Thinking; Problem Solving

ABSTRACT

The ordering of difficulty of logic principles and the age of acquisition for each were examined with 160 gifted children (20 each from ages 4 to 11). Five principles of class logic were explored: three orders of enthymemes, i.e., missing conclusion, missing minor premise, and missing major premise; and two additional third order enthymemes, i.e., missing negative conclusion and missing conclusion to a class chain. A hierarchy of difficulty was found with missing conclusions being the easiest, negative conclusions second easiest, minor premises and conclusions to class chains both being third easiest, with the major premise the most difficult. Developmental data indicate that nearly half the responses were correct for missing conclusions as early as age four, while mastery of the major premise was still limited even by age 11. (Author/CL)

 * Reproductions supplied by EDRS are the best that can be made *
 * from the original document. *

ED188376

U.S. DEPARTMENT OF HEALTH,
EDUCATION & WELFARE
NATIONAL INSTITUTE OF
EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY.

FORMAL SYLLOGISTIC REASONING OF YOUNG GIFTED CHILDREN

Irene S. Shigaki

Department of
Curriculum and Instruction
New York University

Willavene Wolf

Department of
Educational Psychology
New York University

Annual Meeting of the
American Educational Research Association
© April, 1979

"PERMISSION TO REPRODUCE THIS
MATERIAL IN MICROFICHE ONLY
HAS BEEN GRANTED BY

Willavene Wolf

TO THE EDUCATIONAL RESOURCES
INFORMATION CENTER (ERIC)."

EC124219

FORMAL SYLLOGISTIC REASONING OF YOUNG GIFTED CHILDREN

Abstract

Curriculum builders recognizing the importance of logical thinking would benefit from research directed to investigating the ordering of difficulty of certain principles of logic and the age at which each principle is acquired. A logic component is particularly important in curricula designed for gifted children. Consequently, subjects for the present investigation were 160 gifted children, 20 each from ages four through eleven. Five principles of class logic were explored: three orders of enthymemes, i.e., missing conclusion, missing minor premise, and missing major premise; as well as two additional third-order enthymemes, i.e., missing negative conclusion and missing conclusion to a class chain. A hierarchy of difficulty was found with missing conclusions being the easiest, negative conclusions second easiest, minor premises and conclusions to class chains both being third easiest with the major premise being most difficult. Developmental data for the gifted children indicated that almost half of the responses were correct for missing conclusions as early as age four, while mastery of the major premise is still limited even by age eleven.

FORMAL SYLLOGISTIC REASONING OF YOUNG GIFTED CHILDREN

Irene S. Shigaki

Department of
Curriculum and Instruction
New York University

Willavene Wolf

Department of
Educational Psychology
New York University

Educators concerned with nurturing the logical abilities of children are increasingly considering the inclusion of some aspects of logic in the curriculum (e.g., Wolf, Huck, and King, 1967; Simcox, 1970). To assist this effort, more systematic information is needed concerning what principles of logic should be introduced at what ages. An early contribution to the field was Hill's 1961 study which found that some six-, seven-, and eight-year-old children are able to recognize valid conclusions derived from sets of given premises, challenging Piaget's contention that formal reasoning does not occur until around ages 11 or 12. Subsequent research by Shapiro and O'Brien (1970) and Sahin (1975) provided further confirmation of Hill's findings, but these researchers cautioned that young children's ability to perform on specific tasks does not imply that logical implications have been completely

This research was supported by a small grant from the Dean's Development Fund of the School of Education, Health, Nursing, and Arts Professions at New York University. The authors express their gratitude to Dr. Donald Scheid for his assistance with test validation and Ms. Patricia Gingrich for her help with data analysis.

mastered. The investigations of these researchers as well as the work of Roberge and Paulus (1971), Ryoti (1972), and others have focused on a child's ability to recognize conclusions to valid syllogisms or to recognize when a syllogism is invalid. Missing from these research endeavors are any studies exploring subjects' ability to recognize or generate missing minor or major premises. Yet, logicians have long acknowledged that when syllogistic reasoning is used in ordinary argumentation, the conclusion and both premises are rarely stated explicitly (Delia, 1970, pp. 146-147; Copi, 1972, p. 224). Consequently, Black advises that: "The most important practical rule to be followed in criticizing specimens of argumentation from real life is make the assumptions explicit" (1952, p. 27). It would seem, therefore, that if the purpose of nurturing logical thinking in children is to enhance their reasoning skills including ability to identify and engage in logical argumentation, a first step would be to determine whether or not children are capable of making missing premises explicit.

When incompletely stated arguments occur, they are called enthymemes and have further been classified as first-order enthymemes where the major premise is unstated, second-order enthymemes where the minor premise is unstated, and third-order enthymemes where both premises are stated but the conclusion is unstated (Copi, pp. 224-225). Thus, an example of a first-order enthymeme would be where the minor premise "Chris is a dog." is presented along with the conclusion "Therefore, Chris likes bones." The missing major premise of this incomplete argument is understood and can be easily supplied from common knowledge resulting in the following completed argument:

All dogs like bones.

Chris is a dog.

Therefore, Chris likes bones.

In argumentation Salmon explains, certain words or phrases indicate that a statement is functioning as a premise or as a conclusion. A common term to denote a conclusion is "therefore" (Salmon, 1963, p. 6). This term indicates that an argument is being presented and that the conclusion follows necessarily from the explicit and implicit premises. Examples of the three orders of enthymemes are presented in Table 1.

Insert Table 1 about here

Recognizing the value of identifying missing premises or conclusions to facilitate logical argumentation, Shigaki and Wolf undertook a study in 1975 to determine the extent to which fifth grade subjects were capable of selecting the appropriate missing element in a multiple-choice test of logic. Their ability to identify these syllogistic elements appeared to vary in a hierarchical order according to the type of proposition: subjects were able to identify 25% of the missing major premises, 45% of the missing minor premises, and 64% of the missing conclusions. To test this hierarchical order, a study was designed and executed with subjects from ages four through ten enrolled in two private schools in New York City (Wolf and Shigaki, 1977). The instrument consisted of syllogisms with one missing proposition presented orally to the child. Syllogisms utilized took the form of major premises being universal

TABLE 1
CLASS LOGIC PRINCIPLES WITH REPRESENTATIVE TEST ITEMS

Principle	Symbolic Form	Sample Test Item
1. First-order enthymeme (Missing major premise)	(All A's are B's.) x is an A. Therefore, x is a B.	Chris is a dog. Therefore, Chris likes bones. Why? (How do you know?) Ans: (All dogs like bones.)
2. Second-order enthymeme (Missing minor premise)	All A's are B's. (x is an A.) x is a B.	All cats meow. Therefore, Dale meows. Why? (How do you know?) Ans: (Dale is a cat.)
3. Third-order enthymeme (Missing conclusion)	All A's are B's. x is an A. (x is a B.)	All fish swim. Jackie is a fish. So? (What follows?) Ans: (Jackie swims.)

TABLE 1 (CONTINUED)

CLASS LOGIC PRINCIPLES WITH REPRESENTATIVE TEST ITEMS

Principle	Symbolic Form	Sample Test Item
4. Third-order enthymeme with particular negative minor premise (Missing negative conclusion)	All A's are B's. x is not a B. (x is not an A.)	All Mary's books are yellow. This book is not yellow. So? (What follows?) Ans: (This book is not Mary's.)
5. Third-order enthymeme with two universal affirmative premises (Class chain)	All A's are B's. All C's are A's. (All C's are B's.)	All those who play in the park run fast. All the children in Mrs. Jones' class play in the park. What else is true? Ans: (All the children in Mrs. Jones' class run fast.)

affirmative statements (All A's are B's), and of conclusions and minor premises being particular affirmative statements (x is an A or x is a B). The results of that study provided partial support for the hierarchical ordering in that a significant difference was found in the children's ability to generate missing major premises as compared to missing conclusions. The range of correct responses for missing major premises was from 5% at age four to 29% at age ten which was more constricted than the range of correct responses for generating missing conclusions, from 19% at age four to 98%, almost total mastery, at age ten. To fully test the hypothesized hierarchy of the three orders of enthymemes and also to determine whether or not a similar pattern concerning the percentage of correct responses by age would be found for precocious children, the population selected for the present study consisted of gifted children. Again, the youngest children in the sample were age four, but the range was extended through age eleven to the beginning of the formal reasoning period identified by Piaget.

Since there was some evidence that two syllogistic patterns: the presence of negation and class chains were both more difficult than simple third-order enthymemes with a missing conclusion (Roberge, 1970), items following these two patterns were included to insure that the instrument which was developed would be difficult enough to challenge the gifted subjects. Syllogisms including a negative term took the form of a universal affirmative major premise (All A's are B's) followed by a particular negative minor premise (x is not a B) with the missing element being a particular negative conclusion (x is not an A). The class chains took the form of a universal

affirmative major premise (All A's are B's), a universal affirmative minor premise (All C's are A's) with the missing element being a universal affirmative conclusion (All C's are B's). All five principles explored in the present study are presented in Table 1 above with their symbolic form and an example of a sample test item for each principle.

Syllogisms with missing conclusions, missing negative conclusions, and missing conclusions to class chains were among the six syllogism types studied by Roberge (1970b) with 4th, 6th, 8th, and 10th grade students as subjects. He reported that his subjects found identification of the correct missing conclusion significantly easier than the identification of the correct missing negative conclusion. In addition, he reported no significant differences between recognition of missing negative conclusions and class chains. However, examination of Table 7 (p. 592) of his report reveals that at grade four 44% of his subjects were able to identify missing negative conclusions while only 35% successfully identified conclusions to class chains. At the sixth grade level 44% were able to identify missing negative conclusions with only 28% recognizing conclusions to class chains. These differences disappear at the 8th and 10th grades and may account for the lack of significant differences between these two principles overall. It appears, therefore, that at grades four and six where mastery of these two principles is still incomplete, they can be ordered in difficulty with missing negative conclusions being easier than class chains.

To recapitulate, Roberge found that identifying the correct missing conclusion was significantly easier for his subjects than identifying the correct missing negative conclusion. The current investigators speculated further that the same hierarchical ordering of difficulty would obtain with missing negative conclusions as with missing conclusions in relation to

missing premises, i.e., generating missing negative conclusions would be easier than generating missing minor premises which in turn would be easier than generating missing major premises. Finally, the data reported by Roberge for his 4th and 6th grade subjects indicate that identifying conclusions and negative conclusions is easier than identifying the missing element to class chains. Since syllogisms with both missing conclusions and minor premises are similar in that they both take the form of a universal affirmative statement followed by a particular affirmative statement, while a class chain consists of two universal affirmative premises, the present investigators postulated that generating conclusions to class chains would be more difficult than generating minor premises.

Hypotheses and research question

Building on the research findings cited above, it was possible to formulate the following two hypotheses concerning the relative difficulty of the five principles of class logic explored in the present study:

Hypothesis 1: There will be a hierarchy of difficulty for all subjects in supplying missing portions of syllogisms with the missing conclusion being supplied most frequently, missing negative conclusion second most frequently, missing minor premise third most frequently, and missing major premise least frequently.

Hypothesis 2: Subjects will find it significantly more difficult to supply conclusions to class chains than to supply missing conclusions, missing negative conclusions, and missing minor premises.

The relationship between missing conclusions for class chains and missing major premises was explored, but since there was no prior research evidence regarding this relationship, no hypothesis was possible.

There has been no research reported in the literature on the formal syllogistic reasoning of young gifted children. Thus, a hypothesis concerning the rate of acquisition of each of the five principles by gifted children at each age level is not possible. Rather, the following research question was explored: For each of the five principles what is the proportion of correct responses for gifted children at each age level, four through eleven?

Method

Sample

The children used in the sample were enrolled in a public school for the gifted with a mixed ethnic population in New York City. Twenty subjects from each of eight different age levels, four through eleven, were randomly selected from each age cohort resulting in a total sample of 160 children. All the children in the sample had been tested with either the Stanford-Binet Intelligence Test or the Wechsler Intelligence Scale for Children upon entrance into the school and had obtained a minimum score of 130. Since slightly different admissions criteria had been utilized for each of the eight age cohorts in an effort to obtain a better integrated student body while maintaining quality, there was some variability in mean IQ scores across the age groups. Thus, the mean IQ for the total sample was 143 with a standard deviation of 11.1, while average IQ's varied among age groups in the sample from 139 for ages six, ten, and eleven to 152 for age four.

Instrumentation

The Shigaki-Wolf Logic Test utilized for the present study was a refinement and extension of an instrument developed for an earlier study

(Wolf and Shigaki, 1977). The 33-item test taps principles related to both class and conditional logic. For this study the 18-item subtest for class logic was utilized. The test included four items each to assess the principles of first-, second-, and third-order enthymemes; and three items each to assess third-order enthymemes with particular negative minor premises and with two universal affirmative premises. Half of the items assessing first-, second-, and third-order enthymemes were drawn from the earlier instrument so that comparisons could be made. Unlike other instruments which have been developed to assess logical abilities of young children, the Shigaki-Wolf Logic Test does not utilize concrete objects nor follow a multiple-choice format (e.g., Ennis, 1971; O'Brien and Shapiro, 1968). Instead, children are requested to generate the appropriate missing element for each syllogism. This approach was utilized to minimize the possibility of guessing and to provide greater assurance that the correct responses of the children reflect understanding. In the earlier instrument it was found that a sample item with a missing conclusion did not influence responses on the test proper, unlike a sample item with a missing minor premise or missing major premise. Therefore, to familiarize the child with the test format, a single sample item with a missing conclusion is included. Finally, to avoid possible reading difficulties and to accommodate children of ages four and five, the test was developed for oral administration using short syllogisms which could easily be retained.

Validity was established for the instrument by having a logician who regularly teaches logic classes at New York University analyze each item to confirm the following: (1) the correct answer to the item, (2) the logical principle that the test item is assessing, and (3) whether each item is a

valid form of that logical principle. Test-retest reliability of the instrument was established with a subgroup of the sample. Five children from each age group five, seven, nine, and eleven for a total of twenty subjects were tested twice on the same test with one week intervening between testing sessions. A different tester administered the instrument for each session. A high reliability of .90 was established on the full scale with a reliability of .83 for the class logic subtest.

Procedure

A team of female testers was carefully trained to administer the test of logic. Included in the training program were sessions devoted to listening to tape recordings of children of various ages responding to the instrument followed by a critique of the procedures. All testers were required to administer the instrument to several children prior to actual data collection and to tape record these interactions. These tapes were reviewed and individual feedback sessions were held to insure that uniform testing procedures would be followed.

Data were collected through an individual oral session with each child in a room apart from his classroom. Each child's responses were recorded on test forms and simultaneously tape recorded. The first few minutes of each session were used to establish rapport, obtain background information on the child, and introduce the test with the sample item. Following the child's response to the sample item, he was told whether or not his answer was correct, and the correct answer was provided. On the test proper, testers were instructed not to indicate to the child whether or not his response was correct, but to merely respond with a noncommittal "OK" before

proceeding to the next item. To provide closure for the child at the end of the session, he was asked a few questions about himself and given the opportunity to listen to that segment of his tape. The child was requested not to share the content of the session with other children. Each session lasted approximately twenty minutes. Counterbalancing to eliminate the effects of tester, room, and time of day was utilized across all age levels.

Each test protocol was scored by two judges working independently. Agreement was obtained on the overwhelming majority of responses. In the few cases of disagreement the tape recordings were consulted and a mutual decision between the two judges concerning the correctness of these answers was reached.

Results

An 8 x 5 factorial analysis of covariance was computed with repeated measures on the last factor (8 levels of age, 5 principles of class logic). To eliminate age group differences due to intelligence, IQ scores were used as the covariate. Since there was an unequal number of items assessing each of the five principles of class logic, raw scores were converted to proportions which in turn were subjected to the arcsine transformation to insure a normal distribution. A .01 level of significance was utilized for all analyses. The results of the analysis are presented in Table 2. As can be seen from this table, significant F values were obtained for the main effects of age ($F=30.776$, $df=7,151$) and class logic principles ($F=212.228$, $df=4,607$). An interaction effect between age and logic principles ($F=3.754$, $df=28,607$) was also found. There was also a significant difference ($F=12.881$, $df=1,151$) between the age groups on the covariate IQ,

indicating that the selection of analysis of covariance was necessary.

Insert Table 2 about here

Tukey's HSD test was utilized to determine where significant differences occurred among class logic principles. The results of the test for differences concerning the main effect of principle confirmed the hierarchy of difficulty postulated in hypothesis 1. Supplying the missing conclusion was the easiest followed by the missing negative conclusion, missing minor premise, and missing major premise in that order. Further, the differences among these four principles were all significant.

Concerning the second hypothesis of the study, class chains were significantly more difficult than conclusions and negative conclusions, but there was virtually no difference between class chains and minor premises; hence, this hypothesis was only partially supported. In addition, the major premise was the most difficult element for the students to generate, being significantly more difficult than the remaining four element types.

To answer the research question posed concerning the proportion of correct responses by principle and by age, these data have been tabulated in Table 3 together with IQ data for each age group. In addition, the Tukey test was utilized to test for differences concerning the main effect of age. Significant differences were found at two-year increments and up for ages four and five, i.e., the differences between ages four and six, four and seven, and the remaining age groups are significant; and significant differences were found at three-year increments and up for age six, i.e., the differences between ages six and nine, six and ten, and six and eleven are

TABLE 2
ANALYSIS OF COVARIANCE FOR AGE AND PRINCIPLE
(Arcsine Transformed Scores)

Source	SS	df	MS	F
Between subjects				
Age	123.164	7	17.595	30.776***
Covariates	7.364	1	7.364	12.881***
Subjects within groups	<u>86.328</u>	<u>151</u>	0.572	
Total	216.856	159		
Within subjects				
Principle	189.980	4	47.495	212.228***
Age x Principle	23.526	28	0.840	3.754***
Covariates	0.000	1	0.000	
Principle x Subjects				
within groups	<u>135.842</u>	<u>607</u>	0.224	
Total	349.348	640		

***Significant beyond the .001 level

significant. Further, the mean correct score for each age level indicates an increment with age from four through nine. Finally, a plateau in correct responses appears to have been reached between ages nine and eleven with little variability in total percentage correct among those age groups.

Insert Table 3 about here

As reported above, there was also a significant age x principle interaction. The Tukey test for interaction effects (Kirk, pp. 268-269) was employed to determine the source of this effect. It was found that there were significant differences between conclusions as compared to class chains, minor premises, and major premises at practically all age levels. The only exception was the nonsignificant difference between conclusions and class chains at age ten. Likewise, there were significant differences between major premises as compared with the remaining four principles in most cases. The exceptions were the lack of significant differences between major premises when compared with negative conclusions and minor premises at only age four, and the lack of significant differences between major premises and class chains at ages four and five. The lack of significant differences at the lower end of the age spectrum reflects the poor performance by these children on these principles. In addition, there were a few scattered significant differences. The difference between conclusions and negative conclusions was significant only at age six. The difference between negative conclusions and class chains was significant only at age seven. Finally, the differences between negative conclusions and minor premises were significant only at ages eight and nine.

TABLE 3
RESPONSES BY AGE AND PRINCIPLE
(Proportion of Items Correct, Unadjusted for IQ)

Age	IQ		Conclusion	Negative Conclusion	Minor Premise	Class Chain	Major Premise	Total
	Mean	S.D.						
11	139	13.2	100.0	95.0	77.5	76.7	6.3	71.1
10	139	8.7	98.7	86.7	72.5	81.7	23.7	72.7
9	144	8.8	100.0	93.3	66.2	78.3	32.5	74.1
8	140	8.9	92.5	80.0	53.7	65.0	21.2	62.5
7	143	10.9	88.7	76.7	52.5	48.3	18.8	57.0
6	139	9.0	85.0	40.0	43.8	40.0	7.5	43.3
5	149	10.2	63.7	41.7	32.5	23.3	7.5	33.7
4	152	12.1	47.5	23.3	21.2	8.3	5.0	21.1
Total	143	11.1	84.5	67.1	52.5	52.7	15.3	54.4

Discussion

In the present study substantial support was obtained for the two hypotheses concerning the relationship of the five principles of class logic under investigation. This finding is of significance for educators concerned with nurturing logical thinking in young children as it can provide information concerning which principles to introduce at what ages for gifted children similar to those in the present sample. By referring to Table 3 above, one can discern a pattern in the acquisition of the five class logic principles across the age groups. The tabled percentages indicate that conclusions are clearly easiest for all age groups, major premises are substantially more difficult for all age groups, and some variability exists across negative conclusions, minor premises, and class chains. As early as age four 47.5% of the conclusions were generated correctly, reaching 100% accuracy by age nine. It would appear that for gifted populations this is a principle which can be nurtured from an early age. For the missing negative conclusion 76.7% were produced correctly by age seven. In addition, an inspection of the errors produced indicated that for the four- through six-year age span the majority of the incorrect responses did not include the necessary negative term, perhaps reflecting insufficient comprehension of its effect. In contrast to the negative conclusion, minor premises and class chains were generated correctly only about 50% of the time by age seven. Only for the major premise did all age groups fail to attain at least 50% accuracy. The most common error for these syllogisms was the repetition of the minor premise preceded by "because," perhaps indicating that the subjects at least realized that the presented conclusion should necessarily follow from the premises.

The only result which did not support the basic hypotheses was the non-significant difference between the minor premise and the class chain. Explanations for this finding include the possibility that these two principles are mastered approximately at the same rate throughout the four through eleven age span or the possibility that the results were influenced by the scoring procedures employed. It may be helpful to further assess the acquisition of these two principles utilizing a different test format such as multiple-choice where the range of possible answers can be closely controlled.

The hierarchical ordering from easiest to most difficult of missing conclusion, missing negative conclusion, and conclusion to class chain is consistent with the ordering of the data for grades four and six reported by Roberge (1970b). It should be noted, however, that Roberge's instrument required students to recognize the correct response rather than to generate it, and his data are percentages of students who have mastered each principle with mastery being defined as answering at least eight of the twelve items for each principle type rather than proportion of items correct. With these differences in mind, it should also be noted that in comparing the nine- and eleven-year-old groups with their comparable age groups in Roberge's study grades four ($\bar{X}$ IQ=106.6) and six ($\bar{X}$ IQ=101.3), there is several years acceleration in the performance of the gifted students.

An interesting finding was the developmental pattern in the ability of children to supply the missing elements to class syllogisms characterized by a steadily increasing increment in the total score between ages four and nine and a plateau effect between ages nine and eleven. Contributing to the plateau effect is mastery of the conclusions portion of the test. As can be seen in Table 3, by age nine all children were able to generate the correct

missing conclusions. Further, by age nine 93.3% of the negative conclusions were correctly produced, thus allowing little or no room for improvement by the older age groups on these principles. Progress on the minor premise principle continued to increase up through the eleven-year-age group. It would be interesting to replicate this study with older age groups to determine if and when total mastery of the minor premise principle is attained by older children. Progress on the class chain principle shows an increase through age ten and then a slight decrease while the major premise principle increases only to age nine and then drops sharply for the ten and eleven-year-old age groups. One possible explanation for the decrease in scores on the major premise principle may be the fact that the ten- and eleven-year-old groups each had a mean IQ of 139, among the lowest mean IQ's for this gifted sample. Inspection of the score on the major premise for the six-year-old group, which also had an average IQ of 139, indicates that this is a good possibility since that group made no progress with the major premise over the five-year-old group. Despite the correction provided by the analysis of covariance, the lower measured intelligence of these groups in comparison to the other groups may have influenced the relatively poor performance on items with missing major premises.

Corroborating data concerning the plateau effect was obtained by the investigators through an inspection of results obtained from one of their former studies (Wolf and Shigaki, 1977). Although the instrument utilized for the present study contained items testing many more logic principles than that of the former study, comparisons on the major premises and conclusions portions of the test was possible. A similar plateau occurred at ages nine and ten in the earlier study which utilized subjects from two private schools

ranging in age from four through ten. There were similarities in the pattern of the data for the two groups. The range of correct responses for missing major premises by age for both groups is about equivalent. Similar to the present study progress on the major premise stopped at age nine in the former study reaching 27.5% correct. The absence of improved performance beyond age nine for both groups on the major premises suggests the possibility of a developmental lag around the ages of nine through eleven. Perhaps the children have gained new insights by this age causing them to work outside the closed format of the syllogism. Another possibility is that the instrument created for the present study contains items assessing the major premise which may vary in difficulty. The range of correct responses for generating missing conclusions, on the other hand, is more constricted and accelerated at the lower end for the gifted sample. While the four-, five-, and six-year-old children in the gifted sample answered 48%, 64%, and 85% of the missing conclusions correctly, the comparable groups from the private school sample answered 19%, 26%, and 64% of the items correctly. This would seem to indicate that intelligence did affect the results on this principle. School personnel at the private schools have reported that the performance of children in their schools is above average. Since IQ data were not available for the private school sample, it is not possible to determine to what extent the two samples varied on this variable.

The present study offers additional information concerning the pattern of acquisition of five principles of class logic by young gifted children. There is still a need to systematically extend research in this area over a wider age span including additional principles of logic. Further, though there is some research investigating errors in formal syllogistic reasoning

utilizing adult samples (e.g., Roberge, 1970a and Dickstein, 1975), research is needed of the errors made by children to provide more insight into the reasoning processes utilized by the young. While the value of this study is primarily heuristic in nature, the findings have practical implications as well. Teachers and curriculum developers, particularly of the gifted, may be assisted by the knowledge that some children as young as age four are able to generate logical conclusions. This knowledge should influence in particular the nature and scope of the elementary school curriculum and equally important teacher expectations and attitudes.

References

- Black, M. Critical thinking: An introduction to logic and scientific method (2nd ed.). Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1952.
- Copi, I. M. Introduction to logic (4th ed.). New York: Macmillan Pub. Co., Inc., 1972.
- Delia, J. G. The logic fallacy, cognitive theory, and the enthymeme: A search for the foundations of reasoned discourse. The Quarterly Journal of Speech, April 1970, 56, 140-148.
- Dickstein, L. S. Effects of instructions and premise order on errors in syllogistic reasoning. Journal of Experimental Psychology, 1975, 104, 376-384.
- Ennis, R. H. Conditional logic and primary school children: A developmental study. Interchange, 1971, 2, 126-132.
- Hill, S. A. A study of the logical abilities of children. (Doctoral dissertation, Stanford University) Ann Arbor, Mich.: University Microfilms, 1961, No. 61-1229.
- Kirk, R. E. Experimental design: Procedures for the behavioral sciences. Belmont, Calif.: Brooks/Cole Pub. Co., 1968.
- O'Brien, T. C., & Shapiro, B. J. The development of logical thinking in children. American Educational Research Journal, November 1968, 5, 531-542.
- Roberge, J. J. A reexamination of the interpretations of errors in formal syllogistic reasoning. Psychonomic Science, 1970, 19, 331-333. (a)
- Roberge, J. J. A study of children's abilities to reason with basic principles of deductive reasoning. American Educational Research Journal, 1970, 7, 583-596. (b)

- Roberge, J. J., & Paulus, D. H. Developmental patterns for children's class and conditional reasoning abilities. Developmental Psychology, 1971, 4, 191-200.
- Ryoti, D. E. Student responses to equivalent inference schemes in class and conditional logic. (Doctoral dissertation, University of Illinois at Urbana-Champaign) Ann Arbor, Mich.: University Microfilms, 1972, No. 73-17, 395.
- Sahin, N. The development of deductive reasoning in children. (Doctoral dissertation, University of Denver) Ann Arbor, Mich.: University Microfilms, 1975, No. 76-1242.
- Salmon, W. C. Logic. Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1963.
- Shapiro, B. J., & O'Brien, T. C. Logical thinking in children ages six through thirteen. Child Development, 1970, 41, 823-829.
- Shigaki, I. S., & Wolf, W. The effects of two modes of indirect training on growth in logic. Unpublished manuscript, 1975.
- Simcox, N. M. Improvement in the logic of eight-year-old children. Educational Review, November 1970, 23, 69-77.
- Wolf, W., Huck, C. S., & King, M. L. Critical reading ability of elementary school children. (Office of Education, U. S. Department of Health, Education, and Welfare, Project No. 5-1040, Contract No. OE-4-10-187) Columbus, Ohio: The Ohio State University, Research Foundation, June 1967.
- Wolf, W., & Shigaki, I. S. The development of deductive logic in young children. Paper presented at the annual meeting of the American Educational Research Association, New York City, April 1977.